CARBON NANO-TUBE FIELD EMISSION DISPLAY HAVING STRIP SHAPED GATE

FIELD OF THE INVENTION

The present invention relates to a carbon nano-tube field emission display having strip shaped gate, more particularly, using the strip shaped gate and the electric force from the side of the gate to confine the diffusion direction of the electron beam in the same direction, and achieve high luminous efficiency.

BACKGROUND OF THE INVENTION

A carbon nano-tube field emission display (CNT-FED) uses screen-printing processes and field emission display technology to achieve the capability of flat display panel from the conventional field emission display. It not only reserves the image quality of cathode-ray tube display but also provides the advantage of saving energy and small volume. Moreover, the above advantages combine the low conductive electric field, the high emission current density and high stability of the carbon nano-tube simultaneously,

so the CNT-FED can be a novel flat display with the advantages of low driving voltage, high luminous efficiency, no view angle problem, low energy consuming, large size and lost cost.

Referring to FIG. 1, the schematic view of a conventional field emission display with a triode structure, the triode structure is a common structure for improving the electron energy, the luminous efficiency and reducing the control voltage. The luminous principle of a conventional carbon nano-tube field emission display is shown in FIG.1, the conventional CNT-FED includes a substrate 101 and a cathode plate 102 formed on the substrate 101; a carbon nano-tube layer formed on the surface of the cathode plate 102 as a electron emitter 103; a dielectric layer 104 formed adjacent to the cathode plates and a gate 105; wherein a plurality of electrons are induced from the cathode plate 102 by the gate 105, and the direction of the electron current is shown as the direction of the arrowhead in FIG.1. After that, an anode plate 107 is provided opposing the cathode plates 102, and a phosphor layer 106 formed on one side of the anode plate 107 is bombarded by the

electron beam, and red, green and blue colors are emitting through the glass substrate 108 to outside.

Referring to FIG. 1, wherein the anode plate 107 of the triode structure is provided to improve the energy of the electrons; the cathode plate 102 is the electron emitter; the gate 105 is provided to attract the electrons. In conventional triode structure, the shapes of most of the gate 105 are hole shaped, and the carbon nano-tube emitter 103 is in the hole of the hole shaped gate 105. The advantage of the hole shaped gate 105 is the electron beam easy control, but the drawback is the electron beam easy diffusing to all-directions. In order to narrow the diffusion of the electrons, the hole shaped gate 105 need to be made very small, extremely smaller than 10 μm.

Referring to FIG. 2, a plan schematic view showing a first hole shaped gate structure of a conventional carbon nano-tube field emission display (Korea Samsung), the triode carbon nano-tube structure is formed on a substrate 101 and the electrons of the carbon nano-tube emitters 103 formed on the cathode in the gate holes 22 are induced by the gates 105, and then they are

accelerated by the anode plate 107 to bombard the phosphor 106 formed on the anode plate (not shown in the figure) and this structure illustrated above is a conventional Spindt type structure. Because of the electrons of the carbon nano-tube emitters 103 induced by the gate holes 22 diffuse to all-directions, it produces the closs-talk phenomenon.

Referring to FIG. 3A through 3C, a schematic view showing a second hole shaped gate structure of a conventional carbon nano-tube field emission display. The carbon nano-tube emitters 103 are provided in the holes of pluralities of gates 105, and said pluralities of gate holes are isolated with each other by a dielectric layer 104, and a cathode plate 102 is provided on the substrate 101, and an anode plate 107 is provided opposing the cathode plates 102. The electric field is formed by the cathode plate 102 and the anode plate 107 and the electrons are induced from the cathode plate 102, so the electrons of the electron emitters 103 are induced by the gates 105 to bombard the phosphor 106 formed on the anode plate 107.

FIG. 3B is a cross sectional schematic view

along the X-direction in FIG. 3A. In the figures, the gate holes formed by the gates 105 and the electron emitters 103 are obvious, and the electrons of the electron emitters 103 are induced from the cathode plates 102 by the gates 105 to bombard the phosphor 106 formed on the anode plate 107. Although the hole shaped gates 105 can control the electron beam, the electron beam easy diffuse to all-directions after leaving the gate holes (as the arrowheads show). As FIG. 3C shows a cross sectional schematic view along the Y-direction in FIG. 3A, the direction of the arrowhead is the direction of the electron beam. Although the electron emitters 103 are around by the gates 105, the electrons of the electron emitters 103 induced by the gates 105 still diffuse to all-directions.

There is one other conventional emitter design, a wedge-shaped emitter, and the emitting mechanical is the same as the Spindt type structure illustrated above. However, in the same field emission array (FEA), the field emission area for the wedge-shaped emitter is larger than the conventional Spindt type structure. But the

electron beam of the wedge-shaped emitter structure still diffuses to bombard the close pixels on the anode plate, produces the closs-talk phenomenon in X and Y directions.

Due to the problems of the conventional FED and the difficult of the screen-printing technology for forming the carbon nano-tube field emission display, a carbon nano-tube field emission display having strip shaped gates is provided according to the present invention. The present invention is using the side electron force of the gates to attract the electrons to control the electron diffusion direction confined in the same direction, and achieves the object of high luminous efficiency.

SUMMARY OF THE INVENTION

The present invention has been made in an effort to solve the above problems.

It is therefore an object of the present invention to provide a carbon nano-tube field emission display having strip shaped gate that achieves high luminous efficiency.

To achieve the above object, the present invention provides a carbon nano-tube field

emission display comprising: a substrate; a plurality of cathode plates formed on the substrate; a dielectric layer formed adjacent to the cathode plates; an anode plate provided substantially parallel and at a distance from the cathode plates; a plurality of light-emitting layers consisted of light-emitting materials formed on a surface of the anode plate opposing the cathode plates. The feature of above-mentioned structure is: a plurality of strip shaped gates and the cathode plates are perpendicular to one another across the dielectric layer, and a carbon nano-tube electron emitter provided on the surface of the cathode plates at the sides of the strip shaped gates. In the structure, the strip shaped gate is now in place of the conventional hole shaped gate, and pluralities of cathode electrons are induced by the electric force from the side of the gate. Therefore, when the carbon nano-tube electron emitter emits electrons, which is controlled under the strip shaped gate, and the diffusion direction of the electron beam is confined in the same direction. Consequently, controlling the image pixel significantly improves the image uniformity and achieves the object of

high luminous efficiency.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a cross sectional schematic view showing a triode structure of a conventional field emission display (FED).

FIG. 2 is a plan schematic view showing a first hole shaped gate structure of a conventional carbon nano-tube field emission display (CNT-FED).

FIG. 3A is a schematic view showing a second hole shaped gate structure of a conventional carbon nano-tube field emission display (CNT-FED).

FIG. 3B is a cross sectional schematic view along the X-direction in FIG. 3A.

FIG. 3C is a cross sectional schematic view along the Y-direction in FIG. 3A.

FIG. 4A is a schematic view showing a carbon nano-tube field emission display (CNT-FED) having strip shaped gates according to a first embodiment of the present invention.

FIG. 4B is a cross sectional schematic view along the X-direction in FIG. 4A.

FIG. 4C is a cross sectional schematic view along the Y-direction in FIG. A.

FIG. 5A is a plan schematic view of the FIG. 4A leaving out the anode plate.

FIG. 5B is a plan schematic view showing a carbon nano-tube field emission display (CNT-FED) having strip shaped gates according to a second embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

FIG. 4A is a schematic view showing a carbon nano-tube field emission display (CNT-FED) having strip shaped gates according to a first embodiment of the present invention that using the electric force from the side of the gate layer 305 to induce cathode electrons. In the structure according to the present invention, an anode plate 307 is on the upper position, so a plurality of electrons of a cathode plate 302 is accelerated by the anode plate 307, and then these electrons bombard a light-emitting layer 306, substantially symmetrical with said cathode plate 302, formed on the anode plate 307 and made of light-emitting materials (ex. phosphor) to improve the luminous efficiency. In addition, as shown in the drawing, the carbon nano-tube field emission display

according to the first embodiment of the present invention includes a substrate 301, and a cathode electrode consist of a plurality of cathode plates 302 formed on the substrate; said cathode plates 302 are formed by screen printing a conductive layer or formed by patterning a metal film via photolithography and etching steps; gate layers 305 are the strip shaped gates set along carbon nano-tube emitters 303; said gate layers 305 are also formed by screen printing a conductive layer or formed by a metal film via photolithography and etching steps and they are at a distance of the substrate and the cathode plates by a dielectric layer 304 that means the dielectric layer 304 provided between the cathode plates 302 and the gate layers 305; the two gate lines at the outside position of the gate layers 305 can also be control electrodes 308; the carbon nano-tube emitters 303 provided on the cathode plates at the sides of the gate layers 305 are formed by screen printing technology, photolithography step plus etching step or photolithography step plus development step; accordingly, the pluralities of emitters 303 can't interfere with each other; said carbon nano-tube

emitters 303 are made of carbon nano-tube material or any emit-able material and achieve the efficiency of the present invention. In the present invention, an anode plate 307 provided at a distance from the substrate 301, wherein a plurality of light-emitting layers 306 formed on a surface of the anode plate 307 opposing, substantially parallel and substantially symmetrical with the cathode plates 302; a accelerated electric field is formed so a plurality of electrons induced from the carbon nano-tube emitters 303 by the gate layers 305 bombards the light-emitting layer 306 to show colors.

The main feature of the structure, the carbon nano-tube field emission display having strip shaped gates according to the present invention, is: the direction of the gate layers 305 (gate electrodes) and the cathode plates 302 (cathode electrodes) are perpendicular to one another, moreover, on the basis of the design of the gate shaped, the gate can attract the electrons from both sides of the cathode plates 302 simultaneously or only one side of the cathode plates 302. Because of the carbon nano-tube emitters 303 is controlled

under the strip shaped gate, (the direction of the arrowhead in FIG. 4C).

In addition, the high accuracy of the pattern alignment is not necessary for the strip shaped gate according to the present invention. Therefore, the advantage of the structure according to the present invention is that the diffusion direction of the electron beams from the carbon nano-tube emitters 303 are confined in the same direction and it can avoid the phenomenon that the electron beams diffused in all-directions according to the conventional hole shaped gates. For the processes, the processes for forming the CNT-FED according to the present invention are easier and the processes yield is improved, moreover, the surface emitting area according to the present invention is more than the conventional CNT emitter (hole shaped gates design).

FIG. 4B is a cross sectional schematic view along the X-direction in FIG. 4A, a hole shaped gate also formed between the two sides of the carbon nano-tube emitters 303 and the gate layers 305, so the electrons still diffuse in all-directions as the direction arrowhead shown in the figure, but

the problem of interference wouldn't happen between the adjacent emitters 303. On the other hand, referring to the FIG.4C, the cross sectional schematic view along the Y-direction in FIG. A, there are no gate layers 305 at two sides of the carbon nano-tube emitter 303, so the electron beam emitted from the nano-tube emitter 303 wouldn't diffuse by the interference of the gate layers 305. The electrons are directly accelerated by the electric field formed between the anode plate 307 and the cathode plates 302, and then bombard the light-emitting layer 306 to improve the luminous efficiency. Consequently, the emitters 303 can't interfere with each other so the interference problem won't happen.

FIG. 5A is a plan schematic view of the FIG. 4A leaving out the anode plate. The function of said parallel strip shaped gate layers 305 is attracting the electrons of the surface of the carbon nano-tube emitters 303 at one side of the cathode plates 302, wherein the two gate lines at the outside position of the gate layers 305 can be a gate or be a control electrode 308 with focus function. In a second embodiment of the present

invention (FIG. 5B), it is possible to use only two parallel strip shaped gate layers 305 to attract the electrons of the surface of the carbon nano-tube emitters 303 at two sides of the cathode plates 302 simultaneously. According to the present invention, using the strip shaped gate and the electric force from the side of the gate can confine the diffusion direction of the electron beam in the same direction.

Although preferred embodiments of the present invention, the carbon nano-tube field emission display having strip shaped gates, have been described in detail herein above. It should be clearly understood that many variations and/or modifications of the basic inventive concepts herein taught which may appear to those skilled in the present art will still fall within the spirit and scope of the present invention, as defined in the appended claims.